Canine heat-related illness (heatstroke) – new perspectives from recent research

This is an accepted manuscript version of the article published by MA Healthcare, available at: https://doi.org/10.12968/coan.2023.0015

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Abstract

Heat related illness (HRI; heatstroke) is a potentially fatal condition in dogs that can be triggered by hot environments or physical activity. Awareness by dog owners and veterinary professionals of the key risk factors and triggers for HRI can promote mitigation strategies to reduce the incidence and severity of the condition. Owners should seek veterinary treatment if their dog develops HRI but should always 'cool first, transport second' before travelling to their vet clinic. Recommended active cooling methods include immersing the animal in water or pouring water over the animal and ensuring air movement, for example using a fan or air conditioning. This article summarises recent research exploring the epidemiology of HRI in UK dogs and aims to debunk common myths related to canine cooling.

Key words: canine heat-related illness; canine heatstroke; canine cooling

Key points

- Owners should be encouraged to learn how to recognise the early signs of heat-related illness, so they can act to limit further progression of the condition.
- If a dog develops heat-related illness, owners should be advised to "cool first, transport second".
- Current guidelines recommend cooling dogs using cold water immersion, or via evaporative cooling (the application of water alongside air movement).

- When grading heat-related illness severity the dog's body temperature should be evaluated alongside presenting clinical signs, as body temperature can change rapidly and may have dropped if the patient has been cooled prior to presentation.

Introduction

Heat related illness (HRI) (heatstroke) is a potentially fatal condition occurring when an animal's body temperature exceeds their ability to thermoregulate (Bouchama and Knochel 2002; Johnson et al. 2006). With rising global temperatures and increased popularity of some predisposed breeds, improved awareness of how to recognise, prevent, and treat HRI is critical to protect canine welfare and save lives.

Triggers

There are two main triggers of HRI in dogs: environmental HRI triggered by exposure to hot environments (e.g. hot vehicle, building, or ambient environmental conditions) and exertional HRI triggered by physical activity typically in (but not limited to) hot conditions (Bouchama and Knochel 2002; Johnson et al. 2006; Hemmelgarn and Gannon 2013). In the UK, exertional HRI accounted for 74.2% of HRI events presenting to primary-care veterinary practices during 2016 (Hall et al. 2020a), supporting a new national campaign Dogs Die on Hot Walks. While most UK exertional HRI events occur following relatively low-intensity exercise during spring and summer, HRI has been reported year-round (Hall et al. 2020a). Wet bulb globe temperature (WBGT) measures ambient conditions, accounting for air temperature, radiant heat, humidity and windspeed to provide a holistic assessment of environmental thermal stress, which all impact the rate at which dogs cool (Hemmelgarn and Gannon 2013). The average WBGT reported for exertional HRI events in UK pet dogs was 16.5°C (Hall et al. 2022).

Confinement in a hot building was the third most common trigger for HRI in the UK, with dogs living in urban areas at greatest risk (Hall et al. 2022). Attending a veterinary practice or grooming parlour was the fourth most common trigger for HRI events (4.6% of HRI events in 2016) (Hall et al. 2020a). Veterinary practices and grooming parlours can be warm, stressful environments for dogs so careful animal monitoring and HRI risk awareness is essential.

Risk Factors

The risk factors identified for HRI include breed, age, bodyweight, and underlying health conditions. Nine breeds in the UK were reported with increased risk of HRI compared to Labrador Retrievers; Chow Chow, English Bulldog, French Bulldog, Dogue de Bordeaux, Greyhound, Pug, English Springer Spaniel, Cavalier King Charles Spaniel, and Golden Retriever (Figure 1) (Hall et al. 2020b).

Breeds with brachycephalic skull shapes had increased HRI risk compared to mesocephalic dogs (Hall et al. 2020b), likely because of decreased ability to thermoregulate through panting and respiration (Schuenemann and Oechtering 2014; Davis et al. 2017). Dogs aged under 2 years had the highest risk of exertional HRI, possibly reflecting increased intensity and duration of exercise undertaken by younger dogs (Hall et al. 2020a). In contrast, dogs over 12 years showed increased risk of environmental HRI compared to dogs <2 years, likely reflecting age-related reductions in thermoregulation mechanisms (Balmain et al. 2018; Hall et al. 2020a). Overweight dogs showed increased risk of HRI. Dogs weighing under 10kg had reduced risk compared to heavier dogs (Hall et al. 2020b).

Figure 1: Dog breeds with increased risk of HRI in the UK (designed by www.pawprintsposters.com)

Clinical Signs and Grading Severity

Dogs, like humans, experience grades of HRI (Figure 2) progressing from mild (characterised by lethargy and altered respiration) to moderate (gastrointestinal disorder, episodic collapse, single seizure) and then severe disease (neurological derangement, bleeding disorders, gastrointestinal haemorrhage, liver/kidney damage). Dogs presenting with severe HRI had 65 times the risk of death compared to dogs with mild HRI (Hall et al. 2022). Therefore, dog owners should be educated to recognise signs of mild HRI, and how to prevent disease progression.

The VetCompass Clinical Grading Tool for Heat-Related Illness in Dogs

Grade	Clinical Signs	Suggested Treatment	Previous Terminology Used for Presentation
Mild	Continuous panting or respiratory effort unresolved following cessation of exercise or removal from hot environment. Lethargy, stiffness or unwilling to move.	Active cooling if hyperthermia present. Rehydration (may be oral only). Supportive care for organ systems affected (e.g., oxygen for dyspnoea). May be able to manage on the scene. Monitor for progression of clinical signs.	Heat stress
Moderate	Progression of mild grade - no response to cooling and/or fluids. Hypersalivation, diarrhoea and/or vomiting (no blood present). A single seizure. Episodic collapse with spontaneous recovery (no impaired consciousness).	Active cooling if hyperthermia present. Rehydration – may require intravenous fluids. Supportive care for organ systems affected (e.g., IV fluids, anticonvulsant drugs). Consider hospitalisation to monitor progression of clinical signs.	Heat exhaustion
Severe	Progression of moderate grade - failure to respond to treatment. Any of: Central nervous system impairment: • Ataxia; • Two or more seizures; • Profound depression; • Unresponsive; • Coma. Liver or kidney dysfunction. Gastrointestinal haemorrhage. Petechiae/purpura.	**Requires hospital care.** Active cooling if hyperthermia present. Monitor and manage hypothermia if develops. If signs of bleeding support with blood products if available. Assess and monitor liver/kidney function (bilirubin, creatinine, urine output, obtain baseline if appropriate). Supportive care for all: • Intravenous fluid therapy, blood glucose and electrolyte management; • Monitor and maintain blood glucose; • Monitor and maintain electrolytes. Supportive care for specific organs/systems: • Neurological support (e.g., osmotic agents, anticonvulsant); • Respiratory support (e.g., oxygen, intubation); • Circulatory support (e.g., vasopressors); • Gastrointestinal support (e.g., antiemetics, GI protectants, antibiotics); • Coagulation system (e.g., blood products).	Heat stroke

Figure 2. The VetCompass clinical grading tool for heat-related illness in dogs, adapted from Hall et al. (2021).

When triaging dogs with suspected HRI, a single body temperature can be misleading when interpreting the presence and/or severity of HRI (Hall et al. 2021). Body temperature measurements must be interpreted alongside patient history and presenting clinical signs. For example, exercising dogs can develop temperatures exceeding 42°C without developing HRI (McNicholl et al. 2016; Carter and Hall 2018). Conversely, dogs may cool once removed from the HRI trigger, particularly if active cooling has been implemented, meaning veterinary professionals may be presented with a normo- or hypothermic dog still suffering severe HRI (Hall et al. 2021).

Myth busting HRI Treatment

Some veterinary texts and canine first-aid advice advocates gradual cooling of dogs with HRI using tepid (not cold) water, claiming that vasoconstriction or shivering from cold water exposure risks further heating the patient or triggering shock (Casa et al. 2007; Hall et al. 2021). Extensive research in human and equine sports medicine has debunked this myth and demonstrated that active cooling using cold water immersion or evaporative cooling (Figure 3) is the most efficient and effective treatment for profound hyperthermia (Marlin et al. 1998; Bouchama et al. 2007; Casa et al. 2007; Gaudio and Grissom 2016; Kanda et al. 2021). Cold-water immersion is therefore recommended for young and healthy dogs, whilst evaporative cooling (spraying the skin and coat with water in combination with air movement) is recommended for geriatric and/or comatose animals or those with comorbidities (Hanel et al. 2016). In dogs, “tap water” at 15-16°C cooled conscious dogs with HRI the fastest, whilst comatose dogs cooled fastest in 1-11°C water (Magazanik et al. 1980). Whilst the application of wet towels is better than no active cooling, water immersion or evaporative cooling is more effective (Foreman et al. 2006).

Figure 3. Evaporative cooling of a dog, the dog has been moved into the shade, water is being applied alongside air movement from a fan.

Published best practice recommendations advocate for active cooling of patients with HRI prior to transporting them for emergency veterinary care (Hanel et al. 2016). During cooling, body temperature should be monitored to avoid hypothermia, although there is mixed evidence on whether hypothermia affects the risk of death (Bruchim et al. 2006; Hall et al. 2021). Rapid cooling is advocated regardless, as duration of temperature elevation beyond the critical temperature (43°C) determines HRI severity (Shapiro et al. 1973); in humans evidence suggests cooling too slowly increases HRI severity (Chen et al. 2023).

Conclusion

Improved veterinary professional awareness of the triggers, risk factors and clinical signs of canine HRI can support improved client education and reduced occurrence of HRI, particularly for predisposed breeds. When HRI does occur, appropriate first aid advice to ‘cool first, transport second’ can help limit disease severity, improving animal welfare and potentially saving lives.

References

Balmain BN, Sabapathy S, Louis M, Morris NR. 2018. Aging and Thermoregulatory Control: The Clinical Implications of Exercising under Heat Stress in Older Individuals. Biomed Res Int. 2018:1–12. doi:10.1155/2018/8306154. https://www.hindawi.com/journals/bmri/2018/8306154/.

Bouchama A, Dehbi M, Chaves-Carballo E. 2007. Cooling and hemodynamic management in heatstroke: Practical recommendations. Crit Care. 11(3). doi:10.1186/cc5910.

Bouchama A, Knochel JP. 2002. Heat Stroke. N Engl J Med. 346(25):1978–1988. doi:10.1056/NEJMra011089. http://www.ncbi.nlm.nih.gov/pubmed/12075060.

Bruchim Y, Klement E, Saragusty J, Finkeilstein E, Kass P, Aroch I. 2006. Heat Stroke in Dogs: A Retrospective Study of 54 Cases (1999-2004) and Analysis of Risk Factors for Death. J Vet Intern Med. 20(1):38–46. doi:10.1111/j.1939-1676.2006.tb02821.x. [accessed 2020 Sep 10]. http://doi.wiley.com/10.1111/j.1939-1676.2006.tb02821.x.

Carter AJ, Hall EJ. 2018. Investigating factors affecting the body temperature of dogs competing in cross country (canicross) races in the UK. J Therm Biol. 72:33–38. doi:10.1016/j.jtherbio.2017.12.006. https://linkinghub.elsevier.com/retrieve/pii/S0306456517304102.

Casa DJ, McDermott BP, Lee EC, Yeargin SW, Armstrong LE, Maresh CM. 2007. Cold Water Immersion: The Gold Standard for Exertional Heatstroke Treatment. Exerc Sport Sci Rev. 35(3):141–149. doi:10.1097/jes.0b013e3180a02bec. http://journals.lww.com/00003677-200707000-00009.

Chen L, Xu S, Yang X, Zhao J, Zhang Y, Feng X. 2023. Association between cooling temperature and outcomes of patients with heat stroke. Intern Emerg Med.(0123456789). doi:10.1007/s11739-023-03291-y. https://doi.org/10.1007/s11739-023-03291-y.

Davis MS, Cummings SL, Payton ME. 2017. Effect of brachycephaly and body condition score on respiratory thermoregulation of healthy dogs. J Am Vet Med Assoc. 251(10):1160–1165. doi:10.2460/javma.251.10.1160. http://avmajournals.avma.org/doi/10.2460/javma.251.10.1160.

Foreman JH, Benson GJ, Foreman MH. 2006. Effects of a pre-moistened multilayered breathable fabric in promoting heat loss during recovery after exercise under hot conditions. Equine Vet J. 38(SUPPL.36):303–307. doi:10.1111/j.2042-3306.2006.tb05558.x. [accessed 2018 Dec 21]. http://www.ncbi.nlm.nih.gov/pubmed/17402437.

Gaudio FG, Grissom CK. 2016. Cooling Methods in Heat Stroke. J Emerg Med. 50(4):607–616. doi:10.1016/j.jemermed.2015.09.014. http://dx.doi.org/10.1016/j.jemermed.2015.09.014.

Hall EJ, Carter AJ, Bradbury J, Barfield D, O'Neill DG. 2021. Proposing the VetCompass clinical grading tool for heat-related illness in dogs. Sci Rep. 11(1):6828. doi:10.1038/s41598-021-86235-w. https://doi.org/10.1038/s41598-021-86235-w.

Hall EJ, Carter AJ, Chico G, Bradbury J, Gentle LK, Barfield D, O'Neill DG. 2022. Risk Factors for Severe and Fatal Heat-Related Illness in UK Dogs—A VetCompass Study. Vet Sci. 9(5):231. doi:10.3390/vetsci9050231. [accessed 2022 May 11]. https://www.mdpi.com/2306-7381/9/5/231/htm.

Hall EJ, Carter AJ, O'Neill DG. 2020a. Dogs Don't Die Just in Hot Cars—Exertional Heat-Related Illness (Heatstroke) Is a Greater Threat to UK Dogs. Animals. 10(8):1324. doi:10.3390/ani10081324.

Hall EJ, Carter AJ, O'Neill DG. 2020b. Incidence and risk factors for heat-related illness (heatstroke) in UK dogs under primary veterinary care in 2016. Sci Rep. 10(1):9128. doi:10.1038/s41598-020-66015-8.

Hanel RM, Palmer L, Baker J, Brenner J-A, Crowe DTT, Dorman D, Gicking JC, Gilger B, Otto CM, Robertson SA, et al. 2016. Best practice recommendations for prehospital veterinary care of dogs and cats. J Vet Emerg Crit Care. 26(2):166–233. doi:10.1111/vec.12455. [accessed 2023 Apr 28]. https://onlinelibrary.wiley.com/doi/10.1111/vec.12455.

Hemmelgarn C, Gannon K. 2013. Heatstroke: thermoregulation, pathophysiology, and predisposing factors. Compend Contin Educ Vet. 35(7):E4. http://www.ncbi.nlm.nih.gov/pubmed/23677841.

Johnson SI, McMichael M, White G. 2006. Heatstroke in small animal medicine: a clinical practice review. J Vet Emerg Crit Care. 16(2):112–119. doi:10.1111/j.1476-4431.2006.00191.x.

http://doi.wiley.com/10.1111/j.1476-4431.2006.00191.x.

Kanda J, Nakahara S, Nakamura S, Miyake Y, Shimizu K, Yokobori S, Yaguchi A, Sakamoto T. 2021. Association between active cooling and lower mortality among patients with heat stroke and heat exhaustion. PLoS One. 16(11):e0259441. doi:10.1371/JOURNAL.PONE.0259441. [accessed 2022 Jan 8]. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0259441.

Magazanik A, Epstein Y, Udassin R, Shapiro Y, Sohar E. 1980. Tap water, an efficient method for cooling heatstroke victims--a model in dogs. Aviat Space Environ Med. 51(9):864–6. [accessed 2018 Aug 16]. http://www.ncbi.nlm.nih.gov/pubmed/7417155.

Marlin DJ, Scott CM, Roberts CA, Casas I, Holah G, Schroter RC. 1998. Post exercise changes in compartmental body temperature accompanying intermittent cold water cooling in the hyperthermic horse. Equine Vet J. 30(1):28–34. doi:10.1111/j.2042-3306.1998.tb04085.x.

McNicholl J, Howarth GS, Hazel SJ. 2016. Influence of the Environment on Body Temperature of Racing Greyhounds. Front Vet Sci. 3:53. doi:10.3389/fvets.2016.00053. [accessed 2018 Jan 22]. http://journal.frontiersin.org/Article/10.3389/fvets.2016.00053/abstract.

Schuenemann R, Oechtering GU. 2014. Inside the Brachycephalic Nose: Intranasal Mucosal Contact Points. J Am Anim Hosp Assoc. 50(3):149–158. doi:10.5326/JAAHA-MS-5991.

Shapiro Y, Rosenthal T, Sohar E. 1973. Experimental Heatstroke a model in dogs. Arch Intern Med. 131(5):688–692. doi:10.1001/archinte.1973.00320110072010. [accessed 2018 Sep 13]. http://archinte.jamanetwork.com/article.aspx?doi=10.1001/archinte.1973.00320110072010.